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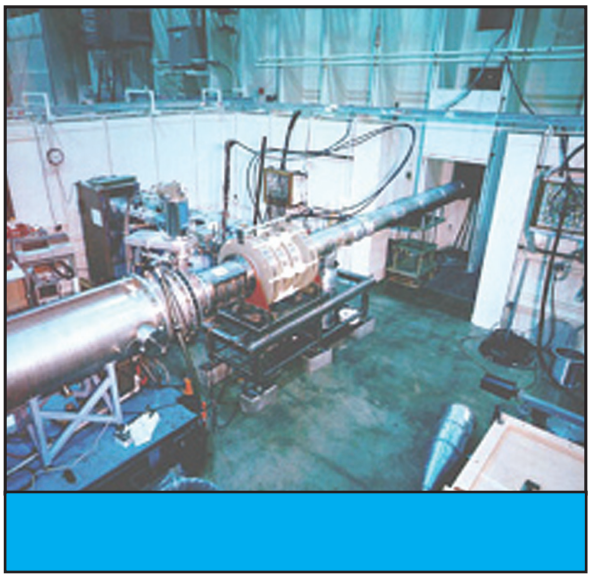
Success Story

HIGH-POWER MICROWAVE SOURCE SOLVES LONG-STANDING EFFICIENCY DILEMMA



Directed Energy Directorate researchers investigated the Relativistic Klystron Oscillator (RKO) as a potential high-power microwave (HPM) source for a number of years. The source currently operates at gigawatt power levels and has high efficiency (>30%). One particularly intriguing feature of the RKO's efficiency, however, eluded explanation over the years.

A number of groups (Mission Research Corporation, The University of Michigan, and The University of California) using two-dimensional simulation, consistently found that the source should be operating at lower power levels than observed in the experimental testing of the device. The directorate used their in-house three-dimensional (3-D) parallel particle-in-cell code, called the Improved Concurrent Electromagnetic Particle-In-Cell (ICEPIC), to model the device in the most comprehensive way possible. This revealed the source of the discrepancy and paved the way for full deployment of this powerful source of HPM radiation.

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Accomplishment

The key feature of the experiment is that the direct current (DC) in the device slowly increases over time when modulated into alternating current (AC) by the radio frequency (RF) cavities. Researchers included this ramping current in ICEPIC simulations. The parallel nature of ICEPIC allows researchers to perform long simulations in full 3-D that mimic the pulsed power drive of the experimental system.

The combined effect of the 3-D structure and the ramping current has shown a new mechanism that enhances the efficiency of extracting RF from the modulated beam. The ramping DC current envelope on a modulated AC current induces a time-varying inductive voltage on the extractor gap. This effect increases the amount of HPM produced. With these effects included, the ICEPIC simulations compare favorably with experimental observations. These new simulations explain, for the first time, the enhanced microwave production seen in the RKO.

Background

Researchers recognize HPM radiation as an effective means of directing energy in military, industrial, and scientific applications. Among the powerful sources currently under development, the RKO stands apart in terms of efficiency and robustness. The new inductive mechanism allows the possibility of exceeding the theoretical maximum efficiencies for relativistic klystrons. The higher efficiency reduces system constraints, leading to smaller pulsed power drivers. The resulting HPM system can therefore be more compact while retaining the high power needed to meet warfighter needs.

Additional information

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